MAINTENANCE

WHEN it comes to a question of maintenance, the attitude of the gyro-officer is a very important factor in obtaining the best results. Most of us who have worked on gyro-compasses have a real feeling of pride about them. There is something very reassuring about the gyro, humming away, as it does, day after day and never ceasing to pick up that tiny crumb of directive energy from the majestic onward movement of the earth. The care of the gyro should never be regarded in the light of a chore to bother the operator and consume his time. The gyro is more than human in its ability to guide the ship accurately through any weather, in any sea, and will repay excessively in faithful service for the small amount of time the gyro-officer need devote to it.

The way to obtain the best results from the compass is to follow the oiling and cleaning instructions undeviatingly and refrain from experimentation. Do not consider the compass as a delicate instrument that has to be babied. Leave it alone except when oiling, cleaning or inspection is required as outlined in the instructions, and if you ever are confronted with an unexpected situation remember that common sense is a very good remedy for most ills. If the situation is carefully thought out, the answer to the trouble will usually be found to be quite simple. To illustrate this point—

Some years ago the service headquarters received an urgent call from a ship, saying that they were nearly ready to sail and that the compass wouldn't settle. A service engineer hastened over to the pier. The gyro-officer met him at the gangplank and explained that he had started the compass several hours before and set it on 22½°, the correct heading of this pier, but for some reason the compass wouldn't stay there. He had set it four times and was very much worried because it kept wandering off, sometimes one way and sometimes the other.

The service man had noticed on coming aboard that the ship was lying at the dock stern upstream which would give a gyro heading of 202½°. The compass was set on this heading and the ship soon went to sea. Obviously an effort was being made to set the compass 180° from its proper heading.

The value of having the proper knowledge in the care of the equipment can be illustrated by another example. We do not wish to cast any reflection on the ability of any officers, but include these incidents because an actual example is often remembered whereas a mere statement may be forgotten.

The gyro in a certain vessel had been handled successfully for four years by a man who had no schooling in its care. This success was mainly due to the fact that he knew so little about the compass he did not care to experiment with it. However, just before leaving for a long cruise, he noticed, for the first time, the wicks in the mercury-ballistic air vents. He realized that he had never oiled these, felt like kicking himself for never having done so—and at once gave them a very thorough oiling all around—enough to make up for the four years in which he had passed them by.

After a few days this quantity of oil plugged the mercury tubes and affected the operation of the compass. Not being able to locate the trouble, the officer called on the radio-operator, a man who had put in three days at the compass school in Brooklyn. The radio-operator remembered a lecture by the instructor at the school in which he had strongly cautioned against oiling the mercury ballistic wicks. The lecture had stuck in his mind

because, as he said afterward, the instructor had illustrated his point with a humorous story of an officer who had once done this.

The radio officer, noticing signs of oil in the vicinity of the wicks, asked the gyro-officer if he had oiled them. He was informed somewhat reluctantly that he had, as the officer was ashamed of his mistake. "Sparks", in true Horatio Alger style, removed the mercury, cleaned out the ballistic tubes, and with new mercury installed, the compass was as good as ever.

Every gyro-compass equipment is supplied with a large, framed oiling and cleaning chart, which is hung up adjacent to the master compass in the compass compartment. When to oil, how much oil to use, and where and when to clean are explained on these charts, and the operator will have no difficulty in locating the proper places on the compass, as the charts are fully illustrated. The compass rotor oil which is used for the main rotor bearing oil wells and for most of the other bearings of the compass can be obtained from the Sperry Gyroscope Company *and no other oil should be used.* This statement is made—not because the compass manufacturer likes to sell oil—but because much money and much time have been spent in experimentation to find out what grade of oil will give the best compass operation.

There was once a gyro-officer who, thinking a small jar of distilled water in the compass room was a new kind of thin rotor oil, replenished his rotor-case oil wells with the contents of the jar. The rotor, though probably highly indignant at this uncalled-for treatment, continued to function well, and no error in the compass indications was apparent.

About forty-eight hours later, when the last drop of water had been drawn up by the oil rings and evaporated, there was a reduction of voltage and an increase of amperage shown on the control panel. The supply current voltage to the compass was checked and found to be normal. The gyro was then stopped and examined, and when it was found that the oil windows showed no oil, the cause of the trouble was quickly determined. The oil wells were replenished with Compass Rotor Oil, and the compass was operated again without further incident.

Many of the adjustments outlined in the following maintenance instructions will never have to be made. Perhaps it would be better not to mention them as doing so always leads to the possibility that some operators will make an erroneous diagnosis and go on to adjust this, that and the other thing, to the detriment rather than the improvement of the compass. However, if the operator will make an honest effort to refrain from adjusting, resetting, or replacing unless he *knows* that he is right, we believe that the full instructions will be of benefit, as there will be some instances undoubtedly where any one of them may really be the answer.

MASTER COMPASS

Routine Inspection

Each Watch

Check repeaters with Master Compass to be sure repeater system is functioning properly. If supply fails for any reason be sure to check and, if necessary, synchronize repeaters as soon as supply is restored.

Check compass by azimuth observation, if possible.

The speed corrector and latitude corrector should be properly reset whenever changes of speed and latitude make resetting necessary, as advised under OPERATION.

Inspect compass to guard against any abnormal condition of operation.

Each Week

Check alarm unit by turning switch on alarm unit and noting that buzzer sounds.

Check all electrical connections to make sure they are tight, clean and free from oil.

Clean and oil parts as indicated on oiling and cleaning charts in master compass room.

Each Month

Check alignment of azimuth motor brushes as described under this heading on the next page.

Clean and oil parts as indicated on charts.

Care of Mercury Ballistic

The mercury ballistic reservoirs are ventilated through small holes in the reservoir tops so that the mercury will not become air bound as it flows from one reservoir to the other. The air which enters the reservoirs is strained through soft felt wicks to keep the mercury as clean as possible. However, due to the presence of this air and the fact that the mercury is constantly agitated by the hunting of the compass, a certain amount of oxidation of the mercury takes place. This takes the form of a film on the surface of the fluid and eventually the film will retard its free movement. For this reason the mercury should be checked about every 3 months to make sure that it flows freely. For economy of up-keep and maintenance, instructions are given here so that the ship's personnel may inspect and, if necessary, change the mercury. It must be borne in mind, however, that the mercury ballistic is the controlling element of the compass and that care must be exercised in handling and adjusting it. The instructions given herein must be followed exactly.

To observe flow of mercury in ballistic, remove tops of reservoirs, unlock case and tilt ballistic from side to side. This must be done only when gyro is *not running*. The mercury should flow freely from one reservoir to the other. The appearance of film on the fluid is not harmful, provided the mercury flows freely. If it does not flow freely, proceed as described below. If it does, replace reservoir tops, but be very careful not to interchange them when replacing.

If the mercury needs changing, remove ballistic from Compass (see following page). Pour out the old mercury, keeping that removed from each set of reservoirs in separate non-metallic containers.

Carefully wipe out reservoirs with a clean cloth moistened with carbon tetrachloride. (Do not use gasoline.) Make sure that all carbon tetrachloride is evaporated from the parts, before replacing the mercury. Clean out mercury tubes with tube (pipe) cleaners, provided in the spare parts box. After using cleaners, blow out tube to remove any lint.

Carefully strain mercury removed from west reservoirs through fine cheese cloth until it is bright and clean. Then pour this mercury back into *one* of the west reservoirs, pouring in a continuous stream so that no air bubbles are trapped in the tube. Repeat process for fluid removed from east reservoirs. *If any mercury is spilled during this process, BOTH sets of reservoirs should be emptied and refilled with fresh mercury found in spare parts box.* Each bottle contains 8 ounces of mercury. Pour 8 ounces into each set of reservoirs as described above. After refilling ballistic with mercury, replace reservoir tops, making sure not to interchange them. *The wicking in the mercury pot covers is to provide ventilation only, and should never be oiled.* Replace ballistic on compass, as described on the following page.

Adjustments and Replacements

To Adjust Lost Motion in Transmitter

Turn the adjusting knob on the top of the transmitter to remove lost motion.

To Replace Transmitter on Lubber Ring

Position the compass card so that it reads to an exact degree. Card may be turned slight amount required by turning azimuth motor shaft.

Turn lost-motion adjusting knob on top of transmitter all the way counter-clockwise to take up, as much as possible, lost motion in transmitter carriage drive.

Place roller carriage on contact segment number 1.

Put transmitter in place and make sure its gear meshes properly with azimuth gear. Insert mounting screws loosely. With card on an even degree, shift transmitter until roller is again positioned on segment, if it was moved while attaching transmitter. Then take up tightly on mounting screws.

Start Compass and repeaters. Check repeater readings and synchronize with Master Compass. If, when compass card is on an exact degree heading, repeaters do not exactly synchronize, loosen mounting screws of transmitter and tap it so that it moves slightly on the elongated mounting holes until repeater readings match exactly with Compass reading.

To Remove and Replace Mercury Ballistic

Remove 2 screws which attach link arm to ballistic frame.

Carefully lower link arm so that it slides easily away from link bearing on bottom of case.

Back off the mercury ballistic bearing studs until they are clear of their bearings. Lower ballistic frame until it is clear of compass and remove from binnacle.

When replacing ballistic, proceed in reverse order from above. The west bearing stud is pinned to its lock nut and should be screwed in as far as it will go. The east stud should be adjusted so that ballistic has about 0.005" side shake when compass is cool. The lock nut should then be taken up so that stud is locked in place. If possible, use feeler gauge to determine the proper side shake. If gauges are not available, the stud may be replaced properly by making a mark on phantom ring in line with slot in stud before removing ballistic. When replacing ballistic, take up on stud until it is tight, then back off until slot is in line with the mark. If this method is used, take care not to back off ½ turn too much. When replacing ballistic, make sure that north side of ballistic frame is on north side of gyro case. A letter N is stenciled on north side of frame. When replacing link arm, make sure it engages link bearing properly before attaching arm to ballistic frame.

To Adjust Azimuth Motor Gear Mesh

Loosen azimuth motor mounting screws.

Position azimuth motor bracket adjusting screw (found under azimuth motor gear guard) so that there is about 1/10° backlash in phantom element. This can be determined by grasping phantom ring and estimating amount of "shake" possible without moving azimuth motor shaft.

This adjustment must be made properly to obtain a satisfactory hunt in the compass and also to prevent overloading azimuth motor. Once this adjustment is made, it is not necessary to remake it unless azimuth motor position has been disturbed. THIS ADJUSTMENT MUST NOT BE USED TO ALTER THE HUNT.

To Adjust Azimuth Motor Brushes

The azimuth motor brushes are clamped in holders mounted on the azimuth motor frame. The brushes should be adjusted so that, when they are seated on the commutator, the brush holders are parallel to each other. To obtain this condition, loosen brush clamping screws, adjust brush and reclamp. When holders are parallel, the distance from commutator to holder is approximately ¼ inch. When brushes are readjusted, sand them in to fit commutator.

To Adjust Lubber Line Plate

This plate is provided on the compass to compensate the reading for small permanent errors. *Do not attempt to remove such errors by twisting the suspension.*

The compensation is made as follows: — Suppose the compass reading is 278 and it has been definitely established (by sun azimuths, bearings, etc.) that the compass has a 2° easterly error. Simply loosen thumb nuts which clamp lubber line plate to lubber ring and shift lubber line so that reading is 280. Reclamp plate. It is then necessary to change each repeater reading so that the repeaters are synchronized with the compass. NOTE: If the plate is moved only a fraction of a degree, the repeater headings should be changed by loosening the transmitter on the compass and shifting it as necessary to make repeater readings correspond to Compass reading.

To Adjust Roll and Pitch Dampers

The roll and pitch dampers are used to reduce the movement of the compass in its gimbals. The pitch damper is of the friction type, having an adjustable friction brush riding on a cam. To adjust

brush to get proper damping action proceed as follows:

Loosen clamping nuts and raise brush off cam far enough to insert a small piece of paper under brush.

Position adjusting nuts, keeping friction brush holder horizontal, so that when clamp nuts are taken up tight it is just possible to withdraw the paper without tearing it.

In heavy weather it may be necessary to take up on the dampers to prevent the compass case from hitting the stops on the vertical ring. *However, as soon as the ship gets out of heavy weather the dampers should be readjusted as described above.* If this is not done, an error in the compass indication may result.

NOTE: Later type compasses are fitted with dash-pot dampers on the roll axes. This type damper requires no adjustment.

CONTROL PANEL

The maintenance of the control panel is as follows:

Keep panel clean and free from oil and grease.

Keep circuit breaker contacts clean and bright.

Test alarm unit every week by turning alarm switch OFF while compass is operating. If alarm does not sound, check alarm battery. Average life of these dry-cells is 3 to 4 months.

Keep 20-ampere fuses in ship's supply fuse sockets.

Keep a 5-ampere fuse in repeater circuit fuse socket.

The carbon pile regulator (used in some installations to keep the 70-volt D-C. supply constant) is a simple and rugged piece of apparatus and is carefully tested and adjusted before shipment. Adjustment of voltage setting, as described in the following, may occasionally be necessary, but otherwise very little attention should be required.

If regulator does not function properly, carefully check all connections to be sure they are complete and tight. If voltage remains too high, probably the regulator coil circuit is open. This can be checked by holding a wrench or a piece of iron close to the magnet. If there is no strong pull, the circuit is open or partly so.

Voltage Regulator Adjustments

The following adjustments should not be attempted until all other possible causes of trouble have been eliminated.

Voltage Adjustment

The voltage which the regulator will hold can be changed ONLY by changing the position of the ¼" nuts on stud to which spring is attached, and which protrude through bracket at left side of regulator. One of these nuts is used merely as a locknut. To raise voltage, the nuts should be screwed farther up on stud, while to reduce voltage they should be screwed farther out. When setting voltage which regulator is to hold, be sure *regulator has reached its normal operating temperature* and that supply voltage is approximately normal. When coil is cold, it tends to regulate to a value lower than normal.

Carbon Pressure Adjustment

If the regulated voltage changes with heavy loads and the fault is not in the connections or the generator, or due to sub-normal operating temperature, the difficulty may be due to lack of pressure on carbons. This can be corrected by means of large knurled nut at left side of carbon pile. To adjust pressure on carbons, have no current on magnet, pull down on armature and screw up on knurled nut until spring arm will just barely go back against its stop when armature is released. Then loosen adjusting nut ½ turn, which will allow arm to go back freely against its stop. NEVER try to change *voltage setting* by adjusting this knurled nut, as this will only result in reducing range of regulator.

Dashpot Adjustment

The dashpot is of the inverted air type, with a graphite plunger and an air vent adjustment. This vent should be adjusted so as to overcome

any tendency to hunt when load is light, or during starting. Care should be taken not to close up vent too much as this will reduce regulator sensitivity. The dashpot is constant in action regardless of temperature changes and its construction is such that it will not become clogged with dust.

Replacement of Carbons

Broken or damaged carbons may be readily replaced by removing one of the porcelain guide rods of the stacks. Care should be taken not to add or omit any carbon plates.

AMPLIFIER PANEL

Except for the "Follow-Up" switch and "Azimuth Motor" switch which are used when starting and stopping the master compass, the operation of the amplifier panel is entirely automatic. The only maintenance necessary should be a periodic inspection to guard against the presence of moisture, dirt or oil.

The current through the azimuth motor armature from the amplifier is indicated on the A-C. ammeter on the amplifier panel and should be approximately 0.4 ampere. This is not a steady indication, but flutters up and down a few hundredths of an ampere. As the rectifier tubes age or after they have been used several thousand hours, it will be found that the azimuth motor current has decreased and may be considerably less than 0.4 ampere. This current can be restored to normal by shorting out some of the azimuth motor armature series resistance R3 on the back of the amplifier panel. If considerable adjustment is necessary, it is recommended that the rectifier tubes be changed.

MOTOR-GENERATOR

Inspect the commutator and brushes every week. If the brushes slide freely in the holders, they will bear upon the commutator with the proper tension. Brushes which have worn down more than ⅜ inch should be replaced.

Sparking, the chief cause of commutator troubles, may be entirely prevented by:

a. Properly sanding in new brushes, when substituting for old ones, until the bearing surface of the brushes conforms perfectly to the curved surface of the commutator.

b. Never allowing oil or carbon dust to collect in the vicinity of the brush holders.

c. Keeping the ship's supply voltage within 10 volts of the normal value.

d. Keeping the commutator surface free from oil, grease, and moisture.

e. Keeping the slots between the commutator bars free from dust and grease.

A dirty commutator should be cleaned with a piece of soft cloth moistened with carbon tetrachloride. Remove all traces of carbon, and polish the commutator preferably with a fresh piece of cloth moistened with alcohol. This will remove any excess carbon tetrachloride and insure proper drying of the insulation. If need be, clean the brush holders in the same manner, after removing the brushes, making sure that the brushes are replaced properly and slide freely in the holders.

A rough commutator should be carefully smoothed with a piece of fine sandpaper while the machine is running. Make sure to remove all copper and carbon dust from vicinity of the brush-holders after this operation. If necessary, clean out the slots between the commutator bars with a sharp piece of hard wood.

The neutral or normal operating position of the brush-holders is set at the factory and is clearly marked by a white line across the brush-holder support and the brush ring. If the machine is disassembled, care should be taken not to shift the brush-holders from their normal marked position. However, should the brush-holders be moved from their proper position, the brush ring to which the brush-holders are attached should be shifted back to its marked position by loosening the clamp screw, moving the ring in the required direction and tightening the screw.

Lubrication

The ball bearings of the motor-generator are packed with grease and require only an occasional additional application of lubricant through the cups provided at each end of the machine. Keep the cups filled with a good grade of bearing grease (such as is supplied in the spare part box.)

The cups should be filled before starting the equipment, and the handles turned down slightly. It will be necessary to give them only about 1 turn every month thereafter.

COURSE RECORDER

Wind clock springs and re-wind roller spring every 3 days, in direction indicated by arrows.

Keep inkwells approximately ¾ full by adding ink once or twice a week, using the dropper provided. The wells may be slipped out of their holders for filling without disturbing the pens.

A primer bulb is supplied for use in starting a flow of ink through the pens. To prime a pen, compress primer bulb, insert pen point in primer hole and slowly release bulb, drawing ink up from the well through the pen. Remove primer and allow pen to bear on chart. When both pens have been primed, move chart up and down under pens to insure that ink flows properly. Once started, the ink will continue to be fed by capillary action.

Do not use ink of any kind other than that originally supplied with the instrument. When a new bottle of ink is opened, use the ink dropper thereafter as a stopper in place of the original cork.

If the instrument is to be out of use for several weeks, it is advisable to empty the inkwells and clean out the pen tubes. The pen tube is cleaned readily by holding the large end up against a hot water faucet, and allowing the water under pressure to scour the tube. Use cold water if hot is not available.

Cleaning Pens

To remove pens from pen arms, push pens straight up off their supporting brackets, one at a time. To avoid bending the pen arm or hinge, hold the hinge on the pen arm with the left hand and push up on the pen with the right hand, guiding the pen carefully and using a steady pressure. Clean pens with hot water every month. If pens are clogged they should be cleaned as described below. When replacing, pens must be pushed down into the brackets from behind, making a tight, sliding fit so that the pens are held in position by the hooks at the top.

The fine stainless steel tip fitted to each pen tube may become partially clogged after considerable use. To clean, an .008" diameter bare copper wire may be inserted in the tip and worked back and forth to loosen any foreign matter, after which the pen should be blown out with pen primer.

Oiling

With the same oil as used for the Master Compass, oil motor shaft ball bearings and moving parts of pen control mechanism sparingly every 6 months. The lubrication places are indicated by red paint. Avoid any excess of oil so as to prevent oil dripping or creeping to paper chart.

Oil the clock about once a year, using only best grade clock oil. Apply with a fine wire flattened slightly at the end, putting one drop only on each of the pivots.

Adjustments

Zone Pen

At the upper end of the zone pen arm is an eccentric stud which can be rotated to adjust the position of the zone pen on the chart. The eccentric shifts the pen arm nearer to or farther from the indicator dial cam. It is necessary to loosen a nut beneath the pen arm before the stud can be rotated. This nut must be tightened again.

Course Pen

The course pen arm is mounted on the 4-wheel trolley by a double-slotted plate which permits shifting the pen vertically, to align it with the zone pen, and horizontally, to align it with the

proper degree line on the chart. The screw which must be loosened to permit the vertical adjustment is located at the top of the pen arm. The horizontal adjustment screw is to the left of the one just mentioned.

ALARM UNIT

The electrical supply for the alarm unit buzzer is obtained from three dry cells in the bottom of the alarm unit. These batteries should be tested every three months individually, and if any one of them is low, all three should be replaced. The life of a dry cell cannot be predicted accurately, and although a battery apparently may be as good as new, its potential may fall off very rapidly at the end of a given period of service. For this reason, regardless of how they test, make it a rule regularly to insert fresh batteries at six month intervals.

GYRO-PILOT

The Gyro-Pilot is a mechanism which, if properly cared for, will give many years of dependable service. The details mentioned below should be faithfully carried out to insure dependable operation and to prolong the life of the equipment.

Control Unit

The bearings in the Control Unit are ball-type, shielded bearings, having a metal shield to prevent dust and dirt from entering the ball race. These bearings are lubricated when the equipment is assembled and will only require, after each period of service, a few drops of light motor oil as a protection against rusting.

Keep the inner and outer surfaces of follow-up rings clean and bright, using a clean cloth moistened with alcohol. Occasionally crocus paper may be used; dust should be wiped out afterward with a dry cloth. Clean the air gaps between ring sections frequently, by passing paper through the gaps. Do not disturb the relative setting of the follow-up ring air gaps.

The brushes should always slide freely in their holders and should bear squarely on the ring surface. The trolleys should always rotate freely in their carriage.

Apply a little cup grease occasionally to the weather and rudder adjustment lead-screws.

The control lever and adjusting knob shafts should receive a few drops of light machine oil at monthly intervals.

Motor Control Panel

Keep the panel clean and dry.

Clean the A-C relay contact points as necessary by polishing with a very fine grade of sandpaper, being sure to remove any dust afterward.

Clean the reversing contactors with #00 sandpaper. Occasionally oil the contactor hinge pins with a few drops of light machine oil. Check contacts for freedom of action at frequent intervals, making sure that armatures move easily without sticking.

Power Unit

Grease gun fittings are provided at lubrication points in the power unit, and are identified by red circles. Apply grease at these points every

few months. Keep the large gear faces well supplied with a heavy, fibrous, heat-resistant grease.

Keep drive motor clean and dry. Do not permit oil or dust to collect inside shell. The sealed bearings on this unit require no lubrication. Examine commutator and brushes at weekly intervals, and keep the commutator clean, using carbon tetrachloride.

Excessive grease may appear on the friction lining of the magnetic clutch and cause slipping. Oil or grease can be removed from friction lining by washing with gasoline and drying with fuller's earth.

The follow-up transmitter bearings are self-lubricated and require no attention.

Dynamotor

Maintain this unit in accordance with best electrical practice. Clean the commutator with carbon tetrachloride. Make sure the brushes are well seated, clean, and free in their holders. Ascertain that brush springs have the proper tension.

Once a year remove the end plates and thoroughly wash the bearings with gasoline. Replace and add fresh ball bearing grease to the grease inlets in the end frame.

General

Because it is installed in the steering engine room away from the immediate sphere of the gyro-officer is no reason that the gyro-pilot power unit and motor control panel should be forgotten. This part of the equipment is exceptionally rugged and requires little attention. The responsibility for its proper operation is the same as though it were in the wheelhouse, however, and it should never be touched by anyone without the knowledge or permission of the gyro-officer.

On most vessels the care of the power unit and other parts of the gyro-pilot in the steering engine room is under the supervision of the engineering department. For this reason, it is recommended that engineer officers familiarize themselves with the gyro-compass and gyro-pilot equipment, and wherever possible, avail themselves of the facilities of the compass schools maintained by the Sperry Gyroscope Company.